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Research highlights

- The research confirms the independent effects of TODs on promoting sustainable travel behaviour
- Urban TODs possess a greater potential to reduce car based travel compared to other neighbourhood types
- The findings verify that transit adjacent development (TAD) is the “evil twin” of TODs
- Travel attitudes and preferences strongly influence commuting mode choices

Commuting mode choice in transit oriented development: disentangling the effects of competitive neighbourhoods, travel attitudes, and self-selection

Md. Kamruzzaman[a 1], Farjana Mostafiz Shatu[b], Julian Hine[c], Gavin Turrell[d]

[a] School of Civil Engineering and the Built Environment, Queensland University of Technology, 2 George Street, Brisbane, Queensland, Australia.

[b] School of Earth Environment and Biological Sciences, Queensland University of Technology, 2 George Street, Brisbane, Queensland, Australia.

[c] School of the Built Environment, University of Ulster, Shore Road, Newtownabbey, County Antrim, BT37 0QB, Northern Ireland, UK.

[d] School of Public Health and Social Work, Queensland University of Technology, Victoria Park Road, Kelvin Grove, Brisbane, Queensland 4059, Australia.

Abstract

This research identifies the commuting mode choice behaviour of 3537 adults living in different types of transit oriented development (TOD) in Brisbane by disentangling the effects of their "evil twin" transit adjacent developments (TADs), and by also controlling for residential self-selection, travel attitudes and preferences, and socio-demographic effects. A TwoStep cluster analysis was conducted to identify the natural groupings of respondents' living environment based on six built environment indicators. The analysis resulted in five types of neighbourhoods: urban TODs, activity centre TODs, potential TODs, TADs, and traditional suburbs. HABITAT survey data were used to derive the commute mode choice behaviour of people living in these neighbourhoods. In addition, statements reflecting both respondents' travel attitudes and living preferences were also collected as part of the survey. Factor analyses were conducted based on these statements and these derived factors were then used to control for residential self-selection. Four binary logistic regression models were estimated, one for each of the travel modes used (e.g. public transport, active transport, less sustainable transport such as the car/taxi, and other), to differentiate between the commuting behaviour of people living in the five types of neighbourhoods. The findings verify that urban TODs enhance the use of public transport and reduce car usage. No significant difference was found in the commuting behaviour between respondents living in traditional suburbs and TADs. The results confirm the hypothesis that TADs are the "evil twin" of TODs. The data indicates that TADs and the mode choices of residents in these neighbourhoods is a missed transport policy opportunity. Further policy efforts are required for a successive transition of TADs into TODs in order to realise the full benefits of these. TOD policy should also be integrated with context specific TOD design principles.

Keyworlds

Commuting Behaviour; Transit Oriented Development; Living Preferences; Travel Attitudes and Preferences; Transit Adjacent Development

[1] Corresponding author. Tel.: +61 (0)7 3138 2510; fax: +61 (0)7 3138 1170. E-mail addresses: md.kamruzzaman@qut.edu.au (Md. Kamruzzaman), farjana.shatu@hdr.qut.edu.au (Farjana Mostafiz Shatu), jp.hine@ulster.ac.uk (Julian Hine), g.turrell@qut.edu.au (Gavin Turrell).

1. Introduction

Transit oriented development (TOD) is a neighbourhood planning concept characterised by relatively higher residential and/or employment density, convenient and connected street patterns (e.g. grid road layout unlike cul-de-sacs), diversified land uses, and centred around high-frequency public transport (PT) services (Cervero and Kockelman, 1997; Renne, 2009). The concept has emerged as a response to the perceived shortcomings of conventional suburban development (Rohe, 2009); which encourages car based travel due to the separation of home and other opportunities (e.g. work) (Forrest and Kearns, 2001). In comparison, TOD encourages undertaking local trips because of the availability of diverse opportunities located within TOD neighbourhoods and consequently fosters the use of non-motorised travel (e.g. walking and cycling) due to the presence of connected and convenient road networks (Bertolini et al., 2009; Transportation Research Board, 2001). However, if motorised travel is needed to participate in distant activities, people have the option to use accessible transport services at TOD nodes (Curtis et al., 2009).

There is enough evidence in the literature to indicate that TODs enhance the use of more sustainable modes of transport (e.g. PT, walking, and cycling as opposed to the car/taxi) (Arrington and Sloop, 2009; Cervero, 2002; Kamruzzaman et al., 2013; Sung and Oh, 2011). These studies, however, provide misleading results because the impacts of two different but opposite factors are found to co-exist together. A positive misrepresentation of the impacts of TOD occurs when factors such as residential self-selection and/or travel attitudes and perceptions are not controlled for. Research frequently indicates that individual attitudes and preferences are more important than the above urban form variables in influencing travel behaviour (Olaru et al., 2011). Attitudinal and perceptual factors which have a significant impact on travel behaviour include environmental concern, car affection (flexibility and comfort), perceived risk of road crashes, ecological norms (obligation) and beliefs (Cools et al., 2009; Elias and Shiftan, 2012; Matthies et al., 2002; Thøgersen, 2006).

Research has also shown that residential self-selection is a much stronger predictor of travel behaviour than urban form (Handy and Clifton, 2001). This means that it is not the urban form but the inclination of people to live in certain types of neighbourhoods (e.g. TOD in this case) that makes the difference in behaviour (Guo and Chen, 2007; Litman, 2012; Pinjari et al., 2007). Therefore, in the absence of factors representing residential self-selection, factors associated with urban form can capture their effects (Kamruzzaman et al., 2014a). The consideration of these factors, however, is very limited in the context of TODs. Recently, these factors have been utilised in travel behaviour research in order to derive a non-spurious relationship between urban form and travel behaviour (Mokhtarian and Cao, 2008; Singleton and Straits, 1999). However, their application is limited due to a lack of related datasets (Bhat and Guo, 2007). Most of these studies have, however, used travel attitudes and preferences to capture residential self-selection effects. The argument put forward is that, for instance, people with a positive attitude towards PT services would prefer to live in a TOD (De Vos et al., 2012). However, this might not be the case, and an individual may prefer to live in TODs and choose not to use PT services but to use other opportunities provided within a TOD (e.g.

quality of neighbourhood, housing cost) (Lund, 2006); or perhaps to keep PT services as an option to use in the future (Kamruzzaman et al., 2013).

In addition to the tension that exists between urban form and travel attitudes and preferences and/or between urban form and residential self-selection in TOD studies, the impacts of TODs are often diluted due to the non-separation of seemingly TOD like neighbourhoods such as transit adjacent development (TAD) where behaviours and attitudes to travel can be different (Kamruzzaman et al., 2014b; Renne, 2009). TADs are also located around PT services but are characterised by mostly homogenous land use patterns, poorly-connected road layout (e.g. predominantly cul-de-sac), and relatively low densities (Duncan, 2011). When the urban form of a TOD is not properly specified, it results in a TAD, and as a result, TADs are considered the 'evil twin' of TODs (Halbur, 2007). Therefore, a station precinct around a suburban train station cannot be tagged as a TOD if it lacks an appropriate urban form (Belzer and Autler, 2002). Unfortunately, researchers have been dealing with TADs as TODs for a long time (Hollenhorst, 2007). For example, recent studies have shown that despite being regarded as a TOD, about 60% of the train stations in the USA do not have the features of a TOD, rather they are more like a TAD or have hybrid features (Renne and Ewing, 2013; TRB, 2004). Little empirical evidence, however, so far exists on the extent to which travel behaviour of people living in TADs varies from that of those living in TODs. The evidence on the impacts of TODs on travel behaviour is also partial because of the inability of prior studies to incorporate the variety of TOD forms (Bertolini, 1999; Center for Transit-Oriented Development, 2010).

Based on the above discussion, what is needed is an understanding of the true impacts of TODs on travel behaviour and the most effective package of urban form if TODs are to make an effective contribution to the reduction of car-based travel. Section 2 describes the methodology used in this research to address these research objectives. Section 3 presents the results of this research. The findings are discussed in policy terms in Section 4.

2. Data and methods

2.1 Study context

In this research, the commuting mode choice behaviour of people living in different types of TOD and non-TOD (e.g. TAD) areas was investigated in Brisbane, Queensland, Australia. An integrated transport and land use policy option has been developed in this context, primarily through facilitating the implementation of TODs, with an estimated cost of $227 billion (Queensland Government, 2009, 2010a). The policy aim is to double the PT trip share (from 7 to 14 percent) and active transport (from 10 to 20 percent) through reducing the share of car usage (from 83 to 66 percent); and thereby cutting carbon emissions by 33% and reducing congestion (Queensland Government, 2008). The Queensland Government (2010b, p.5) has also identified a number of principles to guide development within TOD precincts which are delineated by "a comfortable 10-minute walk of a transit node (about 800 metres)". The principles included specific residential density, land use diversity, employment intensity, pedestrian connectivity, and PT accessibility levels depending on the type of TOD to be built (see, Table 1 for example) (Queensland Government, 2010b). Guided by these overarching policies, Brisbane City Council (2014) has also undertaken a comprehensive policy to enable the operationalization of TODs within its local settings. A number of TODs currently operational in Brisbane include: Woolloongabba, Yeerongpilly, Bowen Hills, and Coorparoo (Queensland Government, 2010a).

2.2 Data

The HABITAT (**H**ow **A**reas in **B**risbane **I**nfluence Heal**t**h and **A**ctivi**t**y) panel survey data were used in this research in order to investigate the commuting mode choice behaviour between TOD and non-TOD areas in Brisbane. The survey used a multi-stage probability sampling design (Burton et al., 2009; Turrell et al., 2010). First, a stratified random sample of 200 census collection districts (CCDs) was selected from across Brisbane, Queensland, Australia. Second, from within each CCD, a simple random sample was drawn comprising persons aged 40 – 65. The HABITAT survey has collected data in three phases (in 2007, 2009, and 2011) from 11036, 7866, and 6901 adults respectively. This present research used the 2011 version of the data and included a representative analytical sample of 3537 employed individuals (i.e. commuters). Table 2 shows the socio-demographic characteristic of the respondents that were included in this study in order to control for socio-demographic effects on mode choice behaviour. The variables were selected based on the literature (Cools et al., 2009; Fenwick et al., 1983).

2.3 Outcome variables

In the HABITAT survey, respondents were asked to choose the type of transport they used to travel to and from work based on a given complete set of transport mode available in Brisbane including bus, train, ferry, car, walk, motorcycle, bicycle, taxi, and other. Respondents were also instructed to choose multiple options if they used more than one type of transport. The responses were binary coded for each transport mode (i.e. 1 for using a particular mode e.g. bus, otherwise 0). Bus, train, and ferry were combined and referred to as public transport (PT). If a respondent chose any of these as their travel mode, they were coded as 1 otherwise 0. Walk and cycle were also combined and referred to as active transport (AT). Respondents who either walked or cycled were coded 1, otherwise 0. In contrast, car, taxi, and motorcycle were combined to indicate less sustainable modes of transport (LST) and a similar coding system was used for this. This coding system, therefore, allows us to investigate whether people in a particular neighbourhood (e.g. TOD) are likely to use more or less sustainable modes of transport (e.g. PT, AT) compared to their counterparts living in other types of neighbourhood (e.g. TAD).

2.4 Explanatory factors: derivation of neighbourhood typologies

As the purpose of this study was to distinguish between the mode choice behaviour found in different types of neighbourhoods, individuals' living environments were classified into different types of TOD and non-TOD areas. In addition, a specification of respondents' living environment was needed to distinguish between TODs and TADs in order to disentangle the impact of TADs while identifying the impact of TODs on mode choice. This research follows a two-stage procedure to mark these classifications based on the TwoStep cluster analysis method.

The first-stage cluster analysis formed natural groupings of individuals' living environment based on six factors representing urban form (Cerin et al., 2007). The factors were identified from the TOD literature and comprised both residential and employment density (net), public transport accessibility levels (PTALs), diversity of land uses, and street connectivity levels as measured through intersection density, and cul-de-sac density (Kamruzzaman et al., 2013, 2014a). These urban form variables are the key to denote an area as a TOD, or a TAD, or a non-TOD as discussed earlier. The urban form variables were generated using an 800m buffer (network) centred on the home location of each respondent. The buffer size (800m) was selected from the local policy documents as discussed earlier. However, the buffer method was not suitable for the derivation of the employment density variable due to a lack of disaggregated data; instead, the variable was derived at the census collection district (CCD) level.

The data and method used to derive the six indicators have been discussed elsewhere, and are not discussed here in detail (Kamruzzaman et al., 2013, 2014a). Public transport accessibility levels for each individual were calculated using well-known PTAL approaches (see, Transport for London, 2010; Wu and Hine, 2003). Residential density was measured based on the number of residential units located within a unit area of residential zoned land (e.g. number/hectare) of the buffer. Net employment density was calculated based on the number of jobs located within a unit area of employment generating land uses (e.g. commercial, industrial) located within respondents' CCD (e.g. number of jobs/hectares). Land use diversity was calculated using the Simpson's diversity index (Kamruzzaman and Hine, 2013). Intersection density was measured based on the number of 3 or more way intersections located within a unit area of the buffer (e.g. number/hectares) whereas cul-de-sac density was calculated using the number of dead ends located within a unit area of the buffer (e.g. number/hectares).

The first-stage cluster analysis generated a 5 cluster solution (Figure 1). The cluster analysis is very sensitive to outliers in data, and as a result, the sensitivity was reduced by setting the 5% highest and lowest scores equal to the 95th and 5th percentile point respectively (De Vos et al., 2012; Schwanen and Mokhtarian, 2004). A 'fair' cluster quality was reached in this stage (Figure 1). The five clusters were interpreted based on three criteria: a) the mean scores of the urban form variables (Figure 1); b) the location of the clusters in Brisbane as shown in Figure 2; and c) the characteristics of TOD typologies in Brisbane as shown in Table 1. Amongst the five clusters, Cluster 5 was labelled "urban TOD" due to their higher employment and residential densities with good quality PT services. The cluster has highly diverse land use patterns with many intersections and fewer cul-de-sacs. These areas are also located close to the Brisbane CBD. In contrast, Cluster 3 has the highest employment density but a lower level of residential density with moderate public transport services. Given that the activity centre requires a lower residential density but a higher employment density (see, Table 1), these clusters were labelled as "activity centre TOD". In addition, according to Bossard (2002), neighbourhoods in Cluster 4 have the potential of a TOD (in Figure 1) and are labelled as "potential suburban TOD" neighbourhood in this research. Since Cluster 1 and 2 do not qualify for a TOD in any of the indicators (e.g. PTALs, cul-de-sacs), they were referred to as non-TOD areas in this research.

The second-stage cluster analysis was restricted to respondents whose residential locations were identified as non-TODs in the first stage. Again, the analysis in this stage used only the PTALs variable to classify the selected respondents which generated a two cluster solution (Figure 3). Figure 3 shows that respondents belonging to Cluster 2 had higher PTALs. The finding suggests that they were tagged as non-TOD residents in the first-stage because of land use patterns (e.g. low density, diversity, connectivity) – not because of a lack of transport services. Therefore, they were labelled as residing in TADs according to the TAD definition adopted in this research. The remaining individuals were, therefore, labelled as residing in traditional suburban areas. As a result, a five category independent factor was developed classifying respondents as living in: a) traditional suburban neighbourhood; b) TADs; c) activity centre TODs; d) potential suburban TODs; and e) urban TODs.

2.5 Adjustment for potential confounding effects

2.5.1 Derivation of living preferences to control for residential self-selection effects

In the HABITAT survey, participants were requested to specify the importance of 10 factors (statements) that influenced their decision to move into their current address. The importance was measured using a 5-point Likert scale (1 – not at all important to 5 – very important). A factor analysis was conducted using the scores associated with the 10 statements. The analysis was conducted using the principal axis factoring with oblique rotation method (Cao et al., 2007; Handy et al., 2005, 2006). The analysis extracted the fundamental dimensions in data representing the main reasons for selecting the current address. A similar method has been used in the literature in order to take into account self-selection effects (Giles-Corti et al., 2013; Kamruzzaman et al., 2014a). Table 3 shows that the factor analysis generated a 4 factor solution. The strength of the statements associated with each of the factors suggests that the choice of a particular neighbourhood is due to its: a) accessibility and mobility options; b) natural environment; c) child centric facilities; and d) ease of access to work and city. The scores of the four factors were entered into the model in order to control for self-selection in assessing the impacts of TODs.

2.5.2 Travel attitudes and perception

Respondents were also asked to indicate their level of agreement across 12 items representing travel attitudes and preferences. The items were measured using a 5-point Likert scale (1 – strongly disagree to 5 – strongly agree). A similar factor analysis was conducted in order to extract the fundamental dimensions spanned by these 12 items which resulted in a four factor solution (Table 4). The generated factors were interpreted as reflecting respondents' negative perception about public transport (PT), pro-environmentalism, pro-car attitudes, and safety concern attitudes whilst travelling. As with the self-selection factors discussed earlier, the scores of these four factors were also entered into the model in order to disentangle the impacts of travel attitudes and preferences from the impacts of TODs on mode choice behaviour.

2.6 Data analysis

Given that the form of the questionnaire regarding commuting mode yielded a binary outcome, four binary logistic regressions were estimated, one for each of the modes (PT, AT, LST, other). A similar binary model has been used in other research contexts to identify the determinants of mode choice behaviour (Emond and Handy, 2012; Hine et al., 2012; Rose and Marfurt, 2007). Each outcome variable (e.g. PT) was regressed using the 'neighbourhood typology' variable while controlling for other socio-demographic variables, trip characteristics, travel attitudes, and residential preferences. SPSS software (version 21) was used to estimate all models. The odds ratios (ORs) for each explanatory variable were derived based on the binary logistic regression model. The final model included only the statistically significant factors ($p<0.05$) upon refinement of an initial model that included all the explanatory factors.

3. Results

Table 5 shows descriptive statistics of mode choice behaviour between different types of neighbourhood in Brisbane. Overall, 82% of respondents used the LST as their mode of travel to work in 2011. In contrast, 17% respondents mentioned that they used PT services for their travel to work. Only 12% respondents used active transport for travelling to work.

Table 6 shows that the odds of using the less sustainable mode of transport for respondents living in urban TODs were 1.4 times lower when compared to respondents living in traditional suburbs in Brisbane, controlling for all other effects in the model. In contrast, the odds of using PT were 1.5 times higher for respondents living in urban TODs in comparison with respondents living in traditional suburbs. No difference in AT levels was found between urban TODs and traditional suburbs. However, despite having better public transport services which is conducive to walking, respondents living in TADs walked less compared to respondents living in traditional suburbs. In addition, there was no difference in the choice of either PT or LST between TADs and traditional suburbs. These findings suggest that respondents in urban TODs had a significantly higher level of PT and AT usage, and a significantly lower level of LST usage when compared to respondents living in TADs in Brisbane. Surprisingly, similar to TADs, both activity-centre type TODs and potential TODs had very little impact on commuting mode choice behaviour.

As with findings from previous studies, this study confirms a strong influence of travel attitudes and living preferences on commuting mode choice behaviour in Brisbane. Table 6 shows that individuals with higher levels of car dependency or who had a negative perception about PT were significantly more likely to use the car and less likely to use PT services. In contrast, individuals with stronger environmental sensitivity were more likely to use AT. With respect to residential self-selection, Table 6 shows that individuals who were inclined to live in transit friendly neighbourhoods were more likely to use PT services. In contrast, respondents who preferred to live in a neighbourhood surrounded by green/open space had a significantly lower rate of PT usage. Residential self-selection was found not to have any significant effect on the choice of other modes of transport.

4. Discussion and conclusion

This research comprehensively analysed the impacts of TODs on travel behaviour by disentangling the effects of both TADs and self-selection. Previous research has adopted a case study approach and has focused on train stations in identifying the differences in mode choice behaviour between

TODs and TADs (Renne, 2009). In addition, these studies have often chosen neighbourhood types (e.g. TOD vs. TAD) based on subjective judgement. More importantly, rarely, has residential self-selection been taken into account in identifying the impacts of TODs/TADs on mode choice behaviour. This research has attempted to address these weaknesses. It analysed in detail the mode choice behaviour of respondents living within five types of neighbourhoods across Brisbane, Australia: traditional suburbs, TADs, potential TODs, activity centre TODs, and urban TODs. The neighbourhood types were generated using objectively derived indicators of the built environment. The research also controlled for residential self-selection by taking into account respondents' socio-demographics, travel attitudes and perceptions, and residential preference.

Conditional on the definition for different types of neighbourhood used in this study, the findings generally support the hypothesis that individuals living in urban TODs have a higher propensity to use more sustainable modes of transport and a lower propensity to use less sustainable modes (e.g. car, motorcycle, taxi) compared to individuals living in traditional suburbs. However, the commuting mode choice behaviour for those who lived in activity centre TODs, or potential TODs, or TADs is not significantly different from individuals living in traditional suburbs. The findings clearly confirm that such neighbourhoods (e.g. potential TODs or TADs) are the "evil twin" of TODs. This is due to the fact that these neighbourhoods have some features like a TOD neighbourhood (e.g. high PTAL) but have not yet produced the desired behavioural change results (Halbur, 2007). Sieving the neighbourhoods (e.g. between TODs and TADs) therefore enabled the detection of the accurate impact of TODs on mode choice which could have been weakened due to the non-significant influence of TADs. However, given that these neighbourhood types possess some of the qualities of a TOD, they can be transformed into a TOD in order to realise the full benefits of these. The findings from this research confirm that urban transport policy developed around the TOD concept is effective in fostering the use of more sustainable transport modes (e.g. bus, train, walk, bicycle) and reducing car-dependency; and consequently lowering greenhouse gas emissions and congestion levels.

The implications of these findings for policy are significant. Firstly, and not surprisingly, they confirm that travel attitudes and residential area choice are significant determinants of travel behaviour but also importantly indicate that TODs are an extremely important way in which public transport use can be encouraged. This finding clearly suggests that there is more scope for interventions based around the adoption of smart transport measures to shape attitudes and encourage changes in travel behaviour. This work also indicates that both land use planning and complementary transport measures can impact on travel behaviour. Secondly, this study indicates that the transformation of traditional suburbs and TAD neighbourhoods, so that they are more closely aligned with the features associated with TOD neighbourhoods, will produce changes in travel behaviour. Indeed, TAD and traditional suburbs located closer to public transport corridors may offer significant changes in public transport use where the walking environment and pedestrian network is improved, given that the levels of walking were found to be higher in traditional suburbs. Thirdly, the findings indicate that in policy terms activity centre type of TODs need to be more carefully designed to realise the full benefit of TOD investment in terms of residential density, land use mix, and public transport accessibility levels. Finally, the HABITAT survey and the factor analysis results offer insights into the key design considerations required for promoting TOD or TOD related development: proximity to public transport networks, offering easy commuting options to the city and work, quality pedestrian networks, local neighbourhoods with shops, schools and child care facilities.

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6. Figure captions

Figure 1: The TwoStep Cluster Analysis generated five types of neighbourhoods in the first stage

Figure 2: Distribution of TOD and TAD neighbourhoods in Brisbane

Figure 3: The second stage PTALs based cluster analysis of non-TOD individuals resulted in a two cluster solution

Tables

Table 1: Suggested design parameters for different types of TODs in Queensland (Queensland Government, 2010)

TOD type	Dwelling density (dwelling/hectare)	Land use diversity	Commercial plot ratio[a]	Transit
City centre	100+ / 300+	Residential 30%, commercial 40%, retail 20%, community 10%	5:1	-Peak hour frequency: 15 minutes -Off-peak frequency: not more than 30 minutes -18-24 hour transit services -Dedicated routes
Activity centre	40+ / 140+	Residential 50%, commercial 25%, retail 15%, community 10%	3:1	
Specialist activity centre	40+ / 120+	At least 20% residential, at least 10% retail, commercial or community	2:1	
Urban	60+ / 180+	Residential 60%, commercial 25%, retail 10%, community 5%	3:1	
Suburban	30-80 / 100+	Residential 70%, commercial 10%, retail 15%, commercial 5%	2:1	
Neighbourhood	30-60 / 80+	Residential 90%, commercial 2.5%, retail 5%, community 2.5%	1:1	

[a] Ratio of commercial floor area to site area.

Table 2: Socio-demographic status of the respondents

Socio-demographics	Frequency	%	Average	Standard deviation
Gender				
Male	1633	46.2		
Female	1904	53.8		
Car availability				
Yes, always	3272	92.5		
Yes, sometimes	163	4.6		
No (ref: yes, always)	53	1.5		
Do not drive (ref: yes, always)	49	1.4		
Employment status:				
Part time	1138	32.2		
Full-time	2399	67.8		
Level of education				
Up to year 12	1098	31.0		
Diploma/certificate	1024	29.0		
Graduate and over	1415	40.0		
Income				
1st quartile (lowest)	364	10.3		
2nd quartile	691	19.5		
3rd quartile	1081	30.6		
4th quartile (highest)	961	27.2		
Missing	440	12.4		
Current living arrangement				
Living alone with no children	492	13.9		
Single parent with >=1 children	239	6.8		
Single and living with friends/relatives	119	3.4		
Couple living with no children	995	28.1		
Couple living with >=1 children	1638	46.3		
Other	54	1.5		
Country of birth				
Australia	2725	77.0		
Other	812	23.0		
Age			54.2	6.2
Household size			2.9	1.3
Health status			3.4	0.9
Travel time				
Less than 15 minutes	971	27.5		
15-30 minutes	1518	42.9		
30-60 minutes	941	26.6		
More than 60 minutes	107	3.0		
N				3537

Table 3: Pattern matrix generated from the factor analyses using the statements on reasons for choosing current address

Items	Factors			
	Accessibility and mobility of places	Natural environment	Child centric facilities	Ease of commuting
Closeness to public transport	0.700	-0.006	0.079	0.024
Ease of walking to places	0.666	0.221	-0.024	-0.039
Wanted to live close to shops	0.730	-0.102	0.038	0.193
Closeness to open space (e.g. parks)	0.133	0.886	0.069	-0.125
Near to green-space or bushland	-0.058	0.658	0.017	0.185
Closeness to schools	0.129	0.023	0.722	-0.130
Closeness to childcare	-0.080	0.023	0.633	0.115
Closeness to the city	0.042	0.085	-0.042	0.602
Closeness to work	0.038	0.012	0.090	0.527
Access to freeways or main roads	0.311	-0.028	0.036	0.386
% of variance explained	32.679	9.359	6.315	4.484
Total variance explained (%)				52.838
Kaiser-Meyer-Olkin Measure of Sampling Adequacy				0.783
Extraction Method				Principal Axis Factoring
Rotation Method				Oblimin with Kaiser Normalization
N				3537

Table 4: Pattern matrix generated from the factor analyses using the statements on travel attitudes and perceptions

Statements/items	Factors			
	Negative perception about PT	Sensitive to environmental externalities	Car dependent	Safety of car
Public transport is inconvenient and unreliable	0.812	0.034	-0.010	-0.073
Travelling by public transport is not very pleasant	0.624	-0.033	-0.077	0.143
Using public transport takes too much time	0.685	0.042	0.095	-0.026
Public transport can sometimes be difficult than driving	0.431	-0.125	0.051	0.080
People need to walk and cycle more to improve the environment	0.027	0.931	-0.005	0.052
People need to walk and cycle more to reduce global warming	0.028	0.790	-0.043	0.046
People need to walk and cycle more to reduce traffic congestion	0.040	0.754	-0.020	-0.017
People need to use public transport more often to reduce traffic congestion	-0.098	0.527	0.049	-0.060
I need a car to do many of the things that I do	0.024	0.048	0.782	0.002
I could not manage pretty well without a car	-0.001	-0.051	0.628	0.023
Travelling by car is safer overall than taking public transport	0.159	0.030	0.030	0.690
Travelling by car is safer overall than walking	-0.061	-0.008	0.015	0.661
% of variance explained	26.029	15.023	6.819	4.231
Total variance explained (%)				52.102
Kaiser-Meyer-Olkin Measure of Sampling Adequacy				0.789
Extraction Method				Principal Axis Factoring
Rotation Method				Oblimin with Kaiser Normalization
N				3537

Table 5. Descriptive statistics showing the choice of travel mode to work by TOD type[a]

	Respondents		Transport mode use (%)					
			PT		AT		LST	
	Frequency	%	No	Yes	No	Yes	No	Yes
Urban TOD	676	19.1	18.2	23.4	17.8	28.7	27.0	17.4
Activity Centre TOD	513	14.5	14.7	13.1	14.5	14.0	13.7	14.7
Potential TOD	1137	32.1	32.2	32.1	32.5	29.8	32.1	32.1
TAD	514	14.5	14.6	14.3	15.4	8.0	11.6	15.2
Traditional suburb	697	19.7	20.3	17.1	19.8	19.5	15.5	20.6
N	3537	100	602 (17.0%)		436 (12.3%)		2893 (81.8%)	

[a] The sum of the percentages may not equal to 100 due to multiple response dataset.

Table 6: The ORs generated from the binary logistic regression analysis of commuting mode choice behaviour[a]

Explanatory factors	Outcome variables: mode of transport to work (1 = yes, 0 = no)			
	Car/taxi/motorcycle	Public transport	Active transport	Other
Neighbourhood type (ref: traditional suburbs)				
Urban TOD	0.693	1.456		0.443
Activity centre TOD			0.711	0.334
Potential TOD				0.384
TAD			0.553	
Built environmental indicators				
Net employment density		0.998	1.004	
Intersection density			0.532	
Cul-de-sac density				0.110
Travel attitudes and preferences				
Negative perception about PT	1.400	0.483		
Sensitive to environmental externalities		0.862	1.147	
Car dependent	2.058	0.437	0.544	1.365
Reasons to choose current address				
Accessibility and mobility of places		1.287		
Natural environment		0.872		
Travel time (ref: less than 15 minutes)				
15-30 minutes	1.591	10.289	0.405	0.158
30-60 minutes	0.634	41.868	0.786	0.173
More than 60 minutes	0.463	59.907		
Socio-demographics				
Female (ref: male)	1.318	1.488	0.699	0.426
Age		0.968		
Car availability (ref: yes, always)				
Yes, sometimes	0.252	5.117	2.928	
No (ref: yes, always)	0.333			
Do not drive (ref: yes, always)	0.127	1.965	3.452	
Employment status: full-time (ref: part time)				0.491
Level of education (ref: upto year 12)				
Diploma/certificate		0.730		
Graduate and over			1.406	0.642
Current living arrangement (ref: living alone)				
Couple living with >=1 children	1.299			
Other			2.178	
Household size		0.840		
Health status	0.838		1.243	1.299
Country of birth: other (ref: Australia)				
Constant	9.608	0.077	0.111	0.201
-2 log likelihood	2725.07	2160.26	2279.75	827.57
Chi^2 (Omnibus tests of model coefficients)	631.72[a]	1064.69[a]	360.27[a]	124.40[a]
Pseudo R^2 (Nagelkerke)	0.27	0.44	0.18	0.15
N				3537

[a] Only statistically signification ORs are reported

Queensland Government (2010) 'Transit oriented development: guide for practitioners in Queensland', The Department of Infrastructure and Planning, Brisbane.

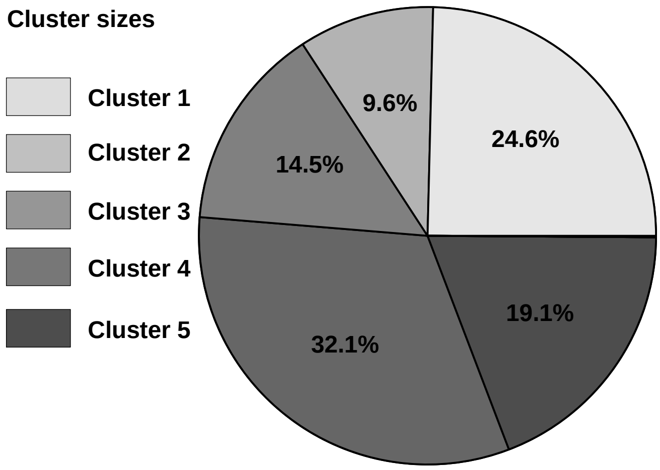
Figure 1

Model summary

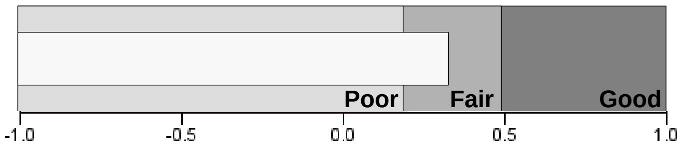
Algorithm	TwoStep
Inputs	6
Clusters	5

Size of smallest cluster	340 (9.6%)
Size of largest cluster	1137 (32.1%)
Ratio of sizes: largest to smallest cluster	3.34

Cluster sizes



Cluster quality



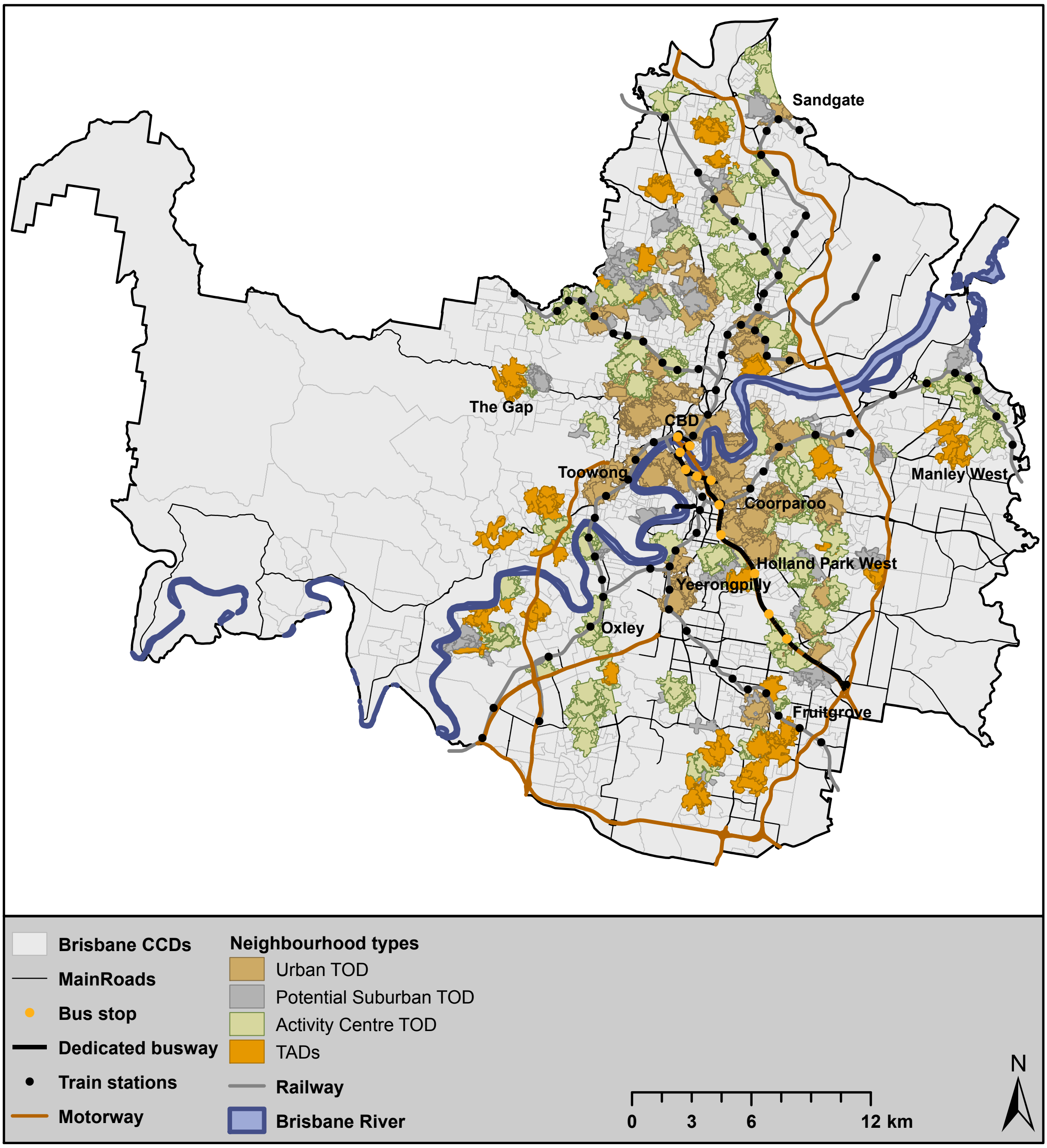
Silhouette measure of cohesion and separation

Input (predictor) importance

1.0 0.8 0.6 0.4 0.2 0.0

Cluster	1	2	3	4	5
Label	Non-TOD	Non-TOD	Activity Centre TOD	Potential Suburban TOD	Urban TOD
Size	24.6% (871)	9.6% (340)	14.5% (513)	32.1% (1137)	19.1% (676)
Inputs	CulDenOut 0.27	CulDenOut 0.19	CulDenOut 0.16	CulDenOut 0.09	CulDenOut 0.11
	EmpDenOut 4.84	EmpDenOut 7.48	EmpDenOut 83.20	EmpDenOut 13.60	EmpDenOut 64.98
	IntDenOut 0.60	IntDenOut 0.34	IntDenOut 0.54	IntDenOut 0.63	IntDenOut 0.71
	NtResDenOut 13.00	NtResDenOut 7.15	NtResDenOut 13.50	NtResDenOut 15.18	NtResDenOut 23.74
	ptal800Out 2.28	ptal800Out 0.75	ptal800Out 2.82	ptal800Out 3.58	ptal800Out 5.67
	DiversityOut 0.38	DiversityOut 0.20	DiversityOut 0.48	DiversityOut 0.46	DiversityOut 0.48

Figure 2



Sandgate
The Gap
CBD
Toowong
Manley West
Coorparoo
Holland Park West
Yeerongpilly
Oxley
Fruitgrove
Brisbane CCDs
MainRoads
Bus stop
Dedicated busway
Train stations
Motorway
Neighbourhood types
Urban TOD
Potential Suburban TOD
Activity Centre TOD
TADs
Railway
Brisbane River
0
3
6
12 km
N

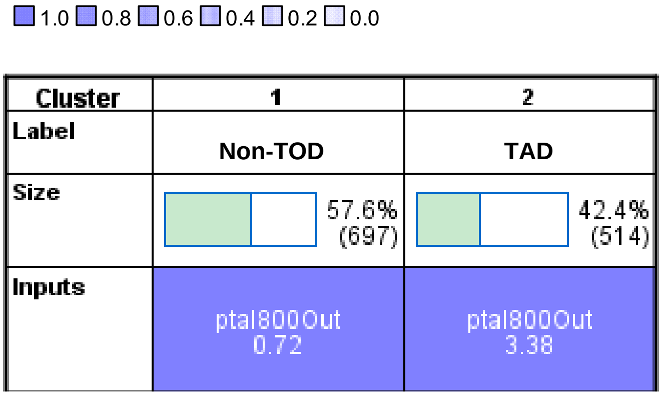
Figure 3

Model summary

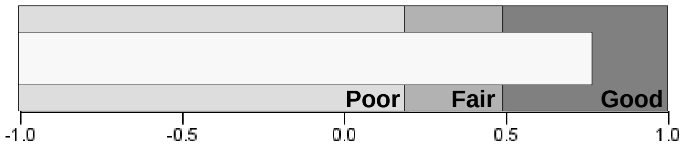
Algorithm	TwoStep
Inputs	1
Clusters	2

Size of smallest cluster	514 (42.4%)
Size of largest cluster	697 (57.6%)
Ratio of sizes: largest to smallest cluster	1.36

Input (predictor) importance



Cluster quality



Silhouette measure of cohesion and separation